

Exploring Requirements for an Adaptive Exercise Selection System

Juliet Okpo
University of Aberdeen
Aberdeen, UK
r02jao15@abdn.ac.uk

Matt Dennis
University of Aberdeen
Aberdeen, UK
m.dennis@abdn.ac.uk

Judith Masthoff
University of Aberdeen
Aberdeen, UK
j.masthoff@abdn.ac.uk

Kirsten A. Smith
University of Aberdeen
Aberdeen, UK
r01kas12@abdn.ac.uk

Nigel Beacham
University of Aberdeen
Aberdeen, UK
n.beacham@abdn.ac.uk

ABSTRACT

In this exploratory focus group study, we investigate which possible characteristics could be considered when selecting exercises for learners and how humans adapt exercise selection to learner personality and performance, so that an Intelligent Tutoring System (ITS) can tailor exercise difficulty to these characteristics. In six focus groups, we had discussed which characteristics of the learner and the exercise could be important for exercise selection. With participants playing the role of the system, we then showed validated stories conveying learner personality traits of Conscientiousness, Self-Esteem and Emotional Stability at high and low levels and an indication of their previous performance on a simple mathematics exercise. Participants were shown an example of the kind of exercises which would be given to learners of varying difficulty and asked to select the exercise which they thought the learner should do next. We observed that participants responded based on the personalities of the learners presented as well as their past performances, with learners high in each trait being given a slightly more difficult exercise than learners low in that trait and learners who performed better being given more difficult exercises than learners who had performed poorly.

Keywords

Learning; Exercise Selection; Adaptation; Personality; Performance

1. INTRODUCTION

The personality of an individual plays a major role in determining how an individual responds to environmental situations [3, 13] and subsequently influences the decision making process of the individual. In the area of task selec-

tion in the learning domain, several characteristics such as past performance, cognitive load and support [2, 4, 5, 20] have determined which next task to give learners. However, the use of personality as a learner characteristic has been relatively unexplored; few works have used personality in selecting tasks for learners.

Learning tailored to individual characteristics has gained relevance in recent times [12, 17, 20, 11]. This learning process has progressed from the use of a fixed predefined pattern of learning tasks for all learners, resulting in better learning outcomes. There is also evidence that certain personality characteristics strengthen or reduce the effect of interest; for example, initiative and persistence are two aspects of action control that independently affect effort expenditure [19].

Disengagement interacts with interest: students who have the skill to uncouple a learning intention from an action plan are more affected by low interest than students who lack this skill [1]. [9] found that an individual's learning orientation, and therefore their approach to learning, is partially determined by their personality. A deep approach to learning was positively associated with extraversion and openness to experience, while a surface approach was positively related to emotional stability and agreeableness. A strategic approach correlated positively with extraversion and conscientiousness and negatively with emotional stability. It is also established that there is a relationship between personality types and/or traits of the learners and their academic success in schools [18]. Therefore, personality should be taken into account when implementing Intelligent Tutoring Systems (ITS) for task selection and not just performance and cognitive load alone to produce better learning outcomes.

As a result of the evident relationships between personality and learning as shown in the above reviews, several adaptations to personality have evolved e.g. [11] adapted linguistic style to personality and [8, 7] adapted feedback to learner personality to improve motivation. Additionally, adaptive learning systems have adapted course and exercise sequencing in lessons to student progress [10].

As defined by [21], a focus group is a group interview which seeks to generate primarily qualitative data by capitalizing on the interaction that occurs within the group setting. Focus groups are usually centred on specific topics. [14] wrote that information saturation can be reached usually after discussions with about six groups. There is

Table 1: Composition of Focus Groups

| Focus Group | Number of participants | Males | Females | Personality Trait | Status |
|-------------|------------------------|-------|---------|---------------------|------------------------|
| FG1A | 4 | 2 | 2 | Conscientiousness | Postgraduate students |
| FG1B | 5 | 2 | 3 | Conscientiousness | Postgraduate students |
| FG2A | 5 | 5 | 0 | Self-esteem | Undergraduate students |
| FG2B | 4 | 4 | 0 | Self-esteem | Undergraduate students |
| FG3A | 7 | 5 | 2 | emotional stability | Undergraduate students |
| FG3B | 8 | 7 | 1 | emotional stability | Undergraduate students |

also the need for a balance in homogeneity for freedom of communication and productive discussions [22]. Therefore, in order to investigate what learner characteristics and task characteristics should be considered when selecting exercises for learners and also to investigate what exercises should be selected based on some these characteristics, specifically personality and past performance, we decided that focus groups were ideal for investigating our aims.

Our major aim for conducting these focus groups is to explore the key learner personality characteristics that are important for an adaptive system to tailor exercise selection. We also explore whether past performance interacts with personality and which other learner characteristics and exercise characteristics should be considered before selecting exercises for learners based on their personality.

2. FOCUS GROUP DESIGN

We conducted six focus groups (FG) because we had three personality traits to explore: Self-Esteem (confidence in one’s own worth or abilities), Emotional Stability (the inverse of neuroticism; being generally calm and less reactive to stress) and conscientiousness (how hard working, careful and thorough one is). We chose these traits to investigate as they seem the most applicable to the learning domain. We ran two focus groups for each trait; FG1A & FG1B investigated conscientiousness, FG2A & FG2B investigated Self-Esteem and FG3A & FG3B investigated emotional stability.

2.1 Participants

As the focus of this study is computer adaptation to learners, we decided to select participants from the computing and learning domain. Participants were recruited from students taking a course in the department of Computing Science at the University of Aberdeen. A total of 33 students participated in the focus groups, including postgraduates and undergraduate students, Table 1 shows the demographic information of participants. Participants were informed that their participation was voluntary and is not a requirement for the course. The focus groups were organised at the University of Aberdeen and the duration for each focus group was 45 – 50 minutes. All focus groups were lead by the same person, supported by two other researchers.

2.2 Research Questions

The focus groups were designed to answer three main research questions:

1. What do we need to know about a learner (learner characteristic) before giving them the next exercise to do?
2. What do we need to know about exercises (exercise characteristics) to know which one to pick next for the learner?

Table 2: Stories depicting High and Low Self Esteem

| SE Level | Story |
|----------|---|
| High | Kate is a student who is confident about her abilities. She is satisfied about the way she looks and feels good about herself. She thinks she is as smart as others and believes that others admire and respect her. She feels that she has a good understanding of things. |
| Low | Nancy is a student who worries about the impression she makes and whether she is regarded as a success or a failure. She feels like she is not doing well and she believes she cannot understand the things she reads. Nancy thinks she is unattractive and is displeased with herself. She feels inferior to others. |

3. What next exercise should be selected for learners with different personalities and performances?

2.3 Procedure

The focus groups began with introduction of participants to each other. Participants were then told that the purpose for the focus groups was to discuss how an e-learning system could automatically adapt exercise selection to different types of learner characteristics. Information sheets and consent forms were distributed amongst participants and the opportunity was given to ask any questions.

We followed a semi structured approach. To answer research question 1, participants were asked: “Which learner characteristics of the learners do you think matter when deciding on a next exercise to give to a learner?”. To answer research question 2, participants were asked “What do you need to know about the exercises to determine which one to pick next?”.

To answer research question 3, participants were shown two students who differ in the same personality trait using personality trait stories (previously validated by [6] as expressing the personality trait at high and low levels; see Table 2 for an example for self-esteem). Participants were shown an example of an exercise that the learner had just completed (see Figure 1), and told one possible past performance from: *they did really well, they just passed, they just failed, they did very badly*.

The participants were then asked to place themselves in the role of the learner’s teacher, and pick the difficulty of next exercise for the learner to do. Participants could choose from: *slightly more difficult, much more difficult, the same difficulty, slightly easier or much easier*.

This procedure was repeated four times for each past performance level for the two learners.

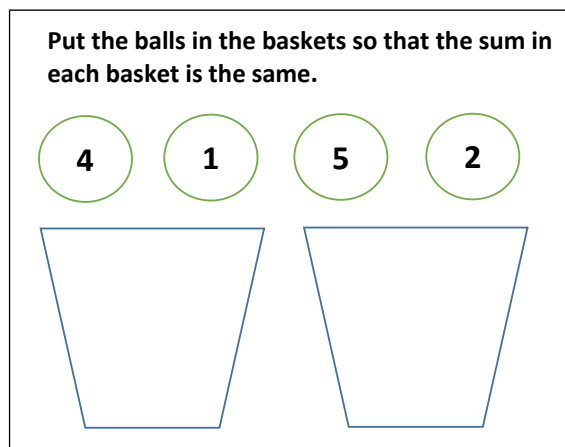


Figure 1: Example Exercise shown to participants

2.4 Ethical Consideration

Consent forms and information sheets were distributed amongst the participants at the start of each focus group and participants were told that any material produced in the group may be used for publication but will be fully anonymised. An audio recording of the sessions was taken with the consent of the participants and notes were made. Taking part in the focus group was voluntary and participants were informed that they were allowed to withdraw from the focus group at any time and for any reason.

2.5 Materials

The materials used to conduct the focus groups were:

- Trait stories expressing personality traits (conscientiousness, self-esteem and emotional stability) at high and low levels
- Exercise card showing a sample of exercise for learners to do
- Performance card showing how the learner performed in previous exercises

3. RESULTS

The focus groups gave the opportunity to discuss some of the characteristics used previously for exercise selection and explore any other characteristics that should be considered. For the purpose of clarity, the results are arranged by responses to the research questions in the order outlined below. Participants answered the questions based on the materials presented to them. We present the results for the answers to questions 1 and 2 for Conscientiousness personality trait (FG1A and FG1B), Self-Esteem personality trait (FG2A and FG2B) and the emotional stability personality trait (FG3A and FG3B) and then question 3 for the same traits listed above. The results from the answers to question 3 spans through the four different conditions: *did well*, *just passed*, *just failed* and *did badly* at high and low levels. These conditions describe the past performances of the learners.

3.1 Q1: Learner Characteristics

Table 3 shows the results for Q1. FG1A were of the opinion that age and performance were appropriate to be considered as learners characteristics when selecting the next exercise for learners. FG1B choose past experience, learning style, competence and emotions (what the learner was feeling) as characteristics to be considered. FG2A mentioned learning styles, knowledge of the exercises, experience, interest in the learning process and past performance. FG2B mentioned the age of the learners and their personality. FG3A mentioned that past performance, learning style, experience, effort and personality should be considered as learner characteristics before giving exercises to learners. FG3B suggested the age of the learner, knowledge of the topic, culture of the learner in relation to the exercises, information available to the learner in relation to the exercise, level of confidence of the learner and experience with the subject area of the exercises '*we could ask about their level of confidence in what we are giving them, like even if you have got a qualification in an area, you might not be very confident in it*'.

Table 3 shows that participants think that age, past performance, past experience, learning style, knowledge and learner personality are most important overall.

3.2 Q2: Exercise Characteristics

This question was not asked in FG1A/FG1B due to time constraints. The learning content in relation with the age of the learners was considered by FG2A. In addition, how interesting the subjects are, difficulty levels and support was suggested. FG2B suggested feedback and the rules governing how the exercises should be done. Both FG3A and FG3B suggested difficulty levels of the exercises ('*we should just scale out from a point onwards, basically go through the steps*').

FG3B also added that the relevance of the exercises to the learners ('*they have to be relevant to the studies the learner is doing*'). They also highlighted the form of presentation of the exercises, past experience with the exercises, support by way of examples available to the learners and the consistency in the structure of the exercises should be considered as exercise characteristics. FG3B also felt the the exercises should be of an appropriate difficulty for the learners ('*You need to give them exercises that they could reasonably do, for example giving them an exercise of which they have no prior knowledge or experience could make them loose confidence*').

Table 3 shows that participants think that exercise difficulty and feedback given are the most relevant exercise characteristics overall.

3.3 Q3: Conscientiousness (FG1A and FG1B)

3.3.1 Did well condition

FG1A choose a more difficult exercise for high conscientiousness learners in this condition. A slightly harder exercise was chosen by FG1B while for learners for low conscientiousness, a slightly harder exercise was chosen by FG1A. FG1B provided no results for the *did well* performance condition.

3.3.2 Just Passed condition

For the high level of this condition, FG1B selected a mixture of more difficult and easier exercises while some of them

Table 3: Identified important learner and exercise Characteristics from all focus groups. Focus group where characteristics were identified marked with X.

| Characteristic | Conscientiousness | | Self-Esteem | | Emotional Stability | |
|----------------|-------------------|------|-------------|------|---------------------|------|
| | FG1A | FG1B | FG2A | FG2B | FG3A | FG3B |
| Learner (Q1) | past performance | X | X | | X | |
| | age | X | | X | | X |
| | learning style | | X | X | | X |
| | past experience | | X | X | | X |
| | emotions | | X | | | |
| | interest | | | X | | |
| | knowledge | | | X | | X |
| | personality | | | | X | X |
| | confidence | | | | | X |
| | culture | | | | | X |
| | competence | | X | | | |
| effort | | | | | X | |
| Exercise (Q2) | time to complete | | X | | X | |
| | relevance | | X | | | X |
| | presentation | | X | | | X |
| | difficulty | | X | | X | X |
| | support | | X | | | X |
| | feedback | | | X | X | X |
| | ground rules | | | | X | |

choose same level of difficulty (*'she is used to succeeding, give her same because if she has easier, she will know and feel bad'*).

For the low level of this condition, FG1B selected same exercise with support. FG1A suggested that different exercises should be given the learner altogether but they should be with the same level of difficulty. They were of the opinion that this will show whether the learner passed by chance or not.

3.3.3 Just failed condition

For the high conscientiousness learner, some participants in FG1B suggested an easier exercise while some choose the same difficulty level exercise. For the low level conscientiousness learner, we had about half of the participants in FG1A and FG1B selecting easier exercises for the learner while the other half selected same level difficulty. A participant in FG1A suggested that a mixture of easier and same level difficulty exercises should be used.

3.3.4 Failed badly condition

For the high conscientious learner, FG1B selected same difficulty exercises while for the low conscientious learner, FG1A suggested that we make the exercises to be of the same level of difficulty but make sure the exercises are not exactly the same as the last one but different altogether. FG1B selected an easier exercise and also mentioned the need to change the approach and method of delivering the learning content.

3.4 Q3: Self-Esteem (FG2A and FG2B)

3.4.1 Did well condition

For the high self-esteem learners, FG2A and FG2B selected a more difficult level exercise. Also, FG2A and FG2B selected a slightly more difficult level exercise for learners

with low self-esteem.

3.4.2 Just passed condition

Learners with high self-esteem were given the same difficulty level exercises by FG2A. FG2B selected a slightly difficult exercise (*'Kate seems like someone who likes a challenge, and maybe the exercises where not challenging enough, so increase the difficulty slightly'*). For learners with low self-esteem, FG2A selected a slightly more difficult exercise, to *'increase difficulty slightly so she does not get really bored'*. In FG2B, 3 participants selected same difficulty levels and just 1 selected an easier exercise.

3.4.3 Just failed condition

For high self-esteem, participants in FG2A decided on the same exercise while participants in FG2B selected an easier difficulty level. On the other hand for low self-esteem learners, both FG2A and FG2B selected exercises with same level of difficulty. They were of the opinion that selecting an easier exercise for this learner will further reduce the already low self-esteem of the learner.

3.4.4 Failed badly condition

FG2A selected an easier exercise for the learner with high self-esteem while FG2B selected same difficulty level. For the low self-esteem learner, both FG2A and FG2B selected an easier exercise for the learner (*'if she got for example only one right, she has to go back and learn the principles all over again'*).

3.5 Q3: Emotional Stability (FG3A and FG3B)

3.5.1 Did well condition

All participants on both FG3A and FG3B selected a more difficult exercise for the high emotional stability learner.

Table 4: Difficulty of selected exercise for all personality traits and learner performance levels. Key: $\hat{\wedge}$ More difficult, \wedge Slightly more difficult, = Same difficulty, \vee Easier, NR No Results

| Trait performance | Conscientiousness | | | | Self-Esteem | | | | Emotional Stability | | | |
|----------------------|-------------------|-----------------------------|-------------|-------------|----------------|----------------|----------|-------------|---------------------|----------------|----------|----------|
| | High | | Low | | High | | Low | | High | | Low | |
| | FG1A | FG1B | FG1A | FG1B | FG2A | FG2B | FG2A | FG2B | FG3A | FG3B | FG3A | FG3B |
| Did well | $\hat{\wedge}$ | \wedge | \wedge | NR | $\hat{\wedge}$ | $\hat{\wedge}$ | \wedge | \wedge | $\hat{\wedge}$ | $\hat{\wedge}$ | \wedge | \wedge |
| Just passed | NR | $\hat{\wedge} \& = \& \vee$ | = | = | = | \wedge | \wedge | $\vee \& =$ | = $\& \wedge$ | = | \vee | = |
| Just failed | NR | $\vee \& =$ | $\vee \& =$ | $\vee \& =$ | \vee | = | = | = | = | = | \vee | NR |
| Failed badly | NR | = | = | \vee | \vee | = | \vee | \vee | \vee | \vee | \vee | \vee |

Also, FG3A and FG3B selected a slightly more difficult exercise for the low neurotic learner.

3.5.2 Just passed condition

For the high emotional stability learner, most of the participants in FG3A and all the participants in FG3B choose same level of difficulty (*'seems like a similar but next level of difficulty because the big important thing about her is that she remains calm under pressure and she probably did the best of her ability'*), (*'should try to push her a little to the next level beyond her present ability and make her smarter, she won't get irritated anyway'*). Two participants in FG3A suggested a slightly harder exercise.

For the low emotional stability learner, participants in FG3A selected a slightly easier exercise, while participants in FG3B selected same exercises. (*'same level as we could not give anything harder because she would be frustrated'*), (*'easier because if Tina sees that she is able to pass, she will be motivated as such a person needs to be shown she is capable of passing a test'*)

3.5.3 Just failed condition

FG3A and FG3B selected the same level of difficulty for learners with high emotional stability personality trait (*'knowing the kind of person that she is she stuff like having a bad day wouldn't influence her that much, so similar level of difficulty should be given to her'*).

For the low emotional stability learner, FG3A selected a slightly easier exercise (*'slightly easier because if she notices that it is much easier, it will make her feel bad about herself'*) with some participants in this group suggesting a combination of easy and difficult exercises for the learner.

3.5.4 Failed badly condition

Both FG3A and FG3B selected easier exercises for learners with high emotional stability that performed very badly and for learner with low emotional stability that performed very badly, an easier exercise was also selected. Interestingly, FG3B agreed that the mood of 'Tina' (the learner with low emotional stability) should be taken into account more than 'Emily': (*'compared to Emily, you need to consider her mood, it could influence her learning'*)

4. DISCUSSION AND CONCLUSION

From the responses, we have discovered that personality, difficulty level of exercises and performance are important characteristics to consider when selecting exercises for learners amongst others. Looking at the results overall (shown in Table 4), we found that all participants selected a more difficult exercise for all learners who did well (as expected).

Learners high in all traits were given a more difficult exercise than learners who were low in the traits, who were only given a slightly more difficult exercise. For the 'just passed' condition, most of the participants choose the same difficulty level for the learners although for low self-esteem learner, a slightly more difficult exercise was selected so as to boost their self-esteem and motivation as agreed by the participants. Again, there was a trend towards learners high in the trait being given slightly more difficult exercises than learners low in the trait. For the 'just failed' condition, most of the participants selected the same exercises, however easier exercises were mostly selected for learners with low conscientiousness and learners with low emotional stability. An easier exercise was selected for almost all the learners that failed badly except for high conscientious and high self-esteem learners who were given exercises of the same difficulty level because the participants were of the opinion that giving them an easier exercise would be demotivating to them.

It seems therefore that, as expected, the performance of the learner is the primary adaptation characteristic for adaptation. However, we found important differences in these adaptations when the personality of the learner was considered. For each of Emotional Stability, Conscientiousness and Self-Esteem, participants thought that learners high in these traits should be given harder exercises than learners low in these traits. This suggests that researchers into intelligent tutoring systems should take learner personality into account when designing exercise selection algorithms. Future empirical studies will investigate (1) how exercise selection can be adapted to learner performance and personality (an initial study is reported in [16]), and (2) the effectiveness of such adaptations in keeping learners motivated and increasing learning outcomes. More information about the project as a whole can be found in [15].

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